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Supplement of

The use of digital twins for waste estimation in nuclear facilities' dismantling and decommissioning: the PLEIADES project

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PLEIADES

Smarter Plant Decommissioning



The use of digital twins for waste estimation in nuclear facilities' dismantling and decommissioning: the PLEIADES project

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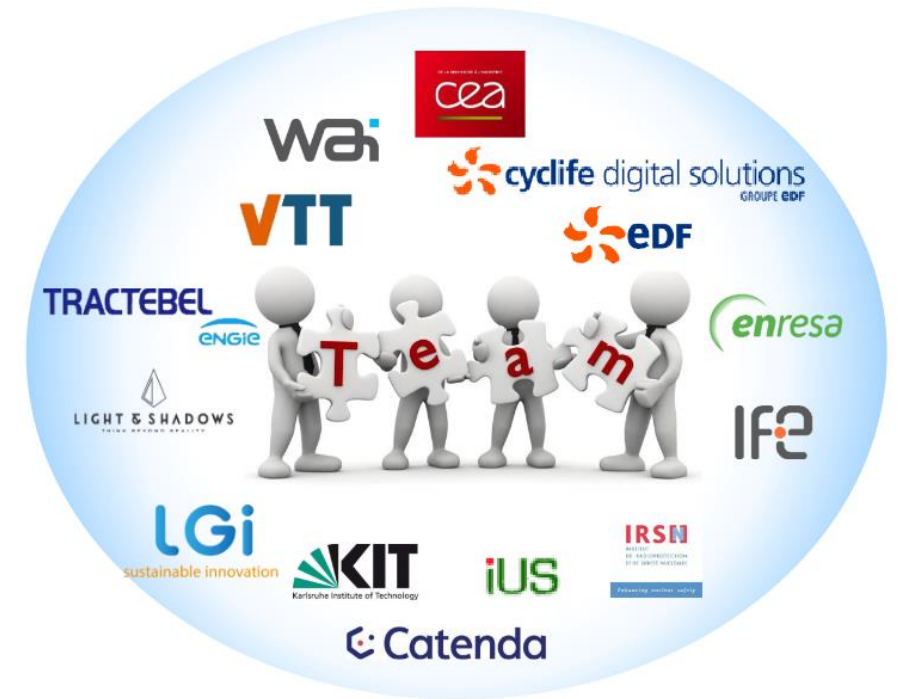
Overview

- Introduction
- Digital Tools
- Objectives
- Demonstration on Real Use Cases
- Organization
- Results
 - Requirements & Specifications
 - PLEIADES Platform Development
 - Development of Digital Models
- The Use of Digital Models
- Summary
- Further Steps
- Sources



Introduction

- **Platform based on Emerging and Interoperable Applications for enhanced Decommissioning processes**
 - **Call: H2020 NFRP-2019-09** – « Fostering innovation in decommissioning of nuclear facilities »
 - **Duration:** 01.10.2020 – 30.11.2023
 - **Consortium:** 14 partners
 - 7 countries: FR (6), DE (2), NO (2), ES (1), FI (1), BE (1), SK (1)
 - 4 academic/research organisations, 1 TSO, 4 industrial companies, 5 SMEs



Source: [1]



Digital Tools

- A number of cutting-edge digital tools is collected and implemented

Sources: [2] [11]

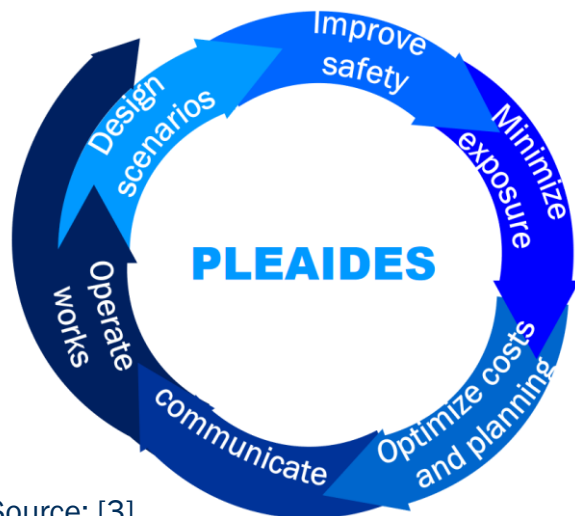
CEA <small>IDROP</small> VR dismantling simulation with collision & radiological modelling	Cyclife DS <small>DEMPLUS</small> Decision-support tool combined with 3D simulation	IFE <small>VRDOSE™</small> Detailed job planning tool with a radiological model library
Catenda <small>BIMSYNC</small> IFC ¹ compatible BIM platform used in construction	WAI <small>AQUILA COSTING</small> ISDC ² compatible client-server based costing tool	IFE <small>RADPIM</small> Radiological characterisation tool (part of VRdose family)
iUS <small>IMS</small> Semantic wiki based nuclear info system	KIT <small>3DSCANPF</small> Robotic platform for 3D scans and imaging	LS <small>INTERACT</small> XR ⁴ platform with physics engine
EDF & CEA <small>DIM TOOL</small> Dismantling Info Modelling system for storing all facility data	VTT <small>ARWORKFLOW ALVAR BIM ACCESS</small> AR ³ training platform with advanced tracking capabilities	Tractebel <small>WASTREAM</small> Waste Routes and Activity Assessment tool

¹IFC: Industry Foundation Classes; ²ISDC: International Stricture for Decommissioning Costing; ³AR: Augmented Reality; ⁴XR: Mixed Reality



Objectives

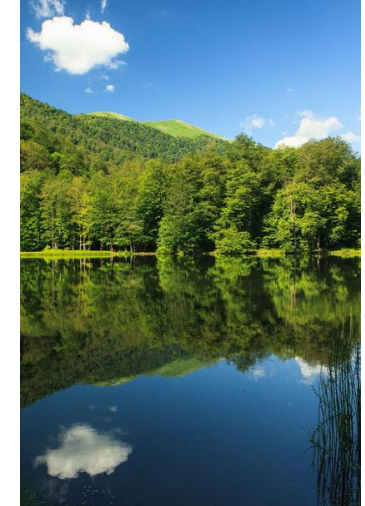
- Main objectives are:
 - Creating a new digital methodology to improve nuclear decommissioning;
 - Definition of an ontology and procedures for the digitization of nuclear facilities' dismantling and decommissioning;
 - Facilitate higher standardization required for international application.
- Ultimate goal is to protect workers, the environment and optimise costs.



Source: [3]



Source: [4]

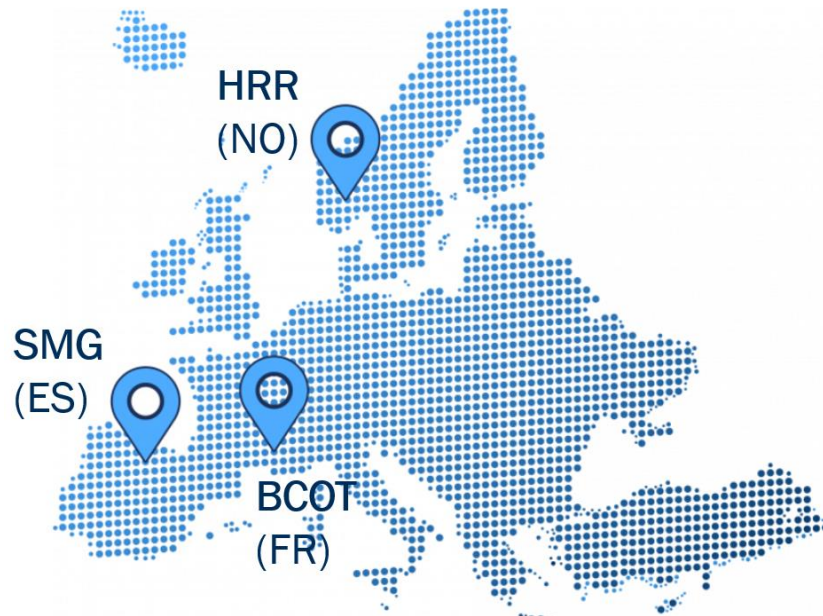


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Demonstration on Real Use Cases

- Application on 3 real use cases in Europe
 - Halden nuclear Research Reactor (HRR), Norway;
 - Santa María de Garona (SMG), Spain;
 - Base Chaude Opérationnelle du Tricastin (BCOT), France.



Source: [5]

Santa María de
Garona (SMG)



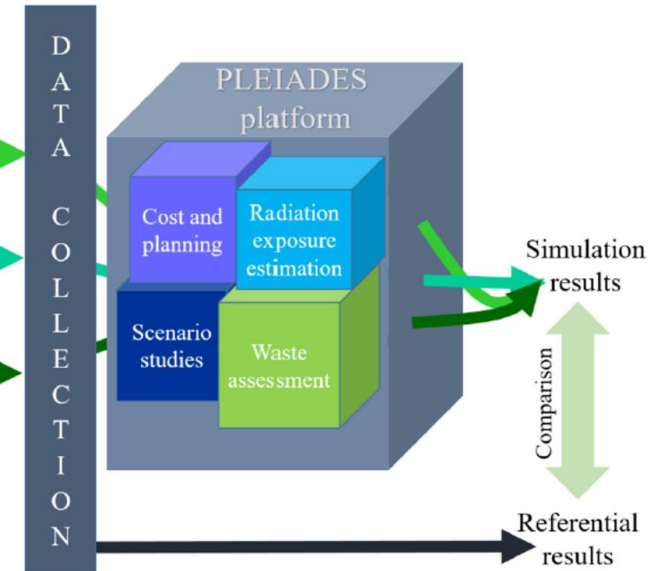
Halden Research
Reactor (HRR)



Basse Chaude O.
du Tricastin (BCOT)



Source: [6]



13-15 September 2023



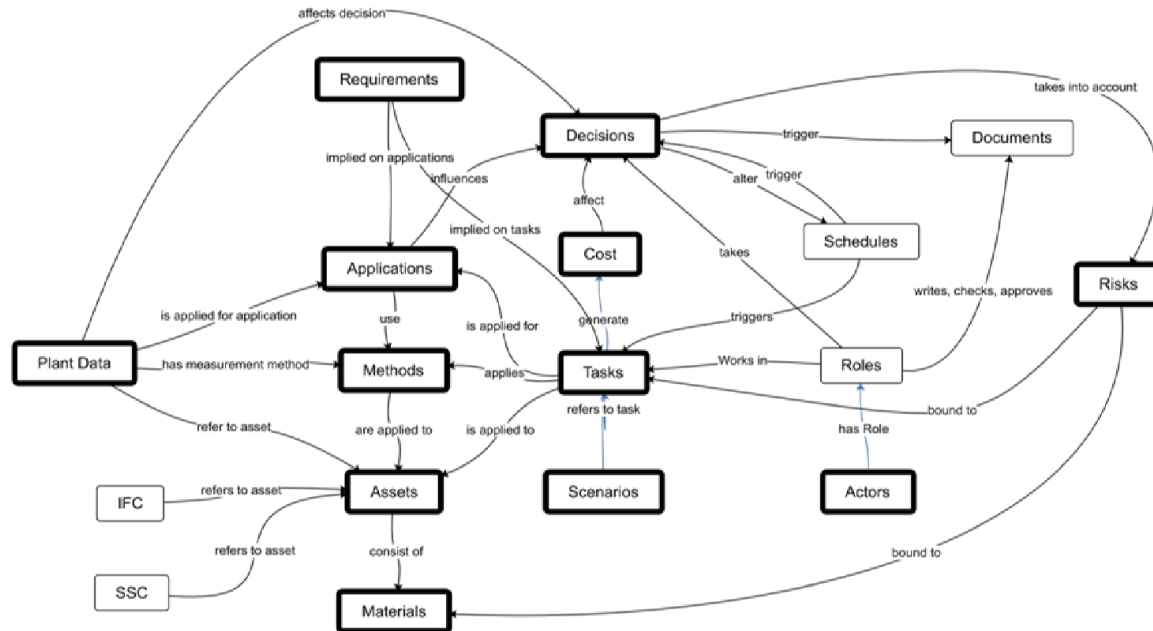
Organization

- 7 Work Packages (WP) in 38 months:
 - **WP1:** Requirement analysis, specification and test design;
 - **WP2:** PLEIADES platform development;
 - **WP3:** Implementation of PLEIADES platform on real use cases;
 - **WP4:** Modelling and results evaluation;
 - **WP5:** Standardisation efforts, exploitation and training;
 - **WP6:** Dissemination, communication & stakeholder engagement;
 - **WP7:** Project coordination and management.



Results: Requirements & Specifications

- Definition of a core nuclear decommissioning ontology

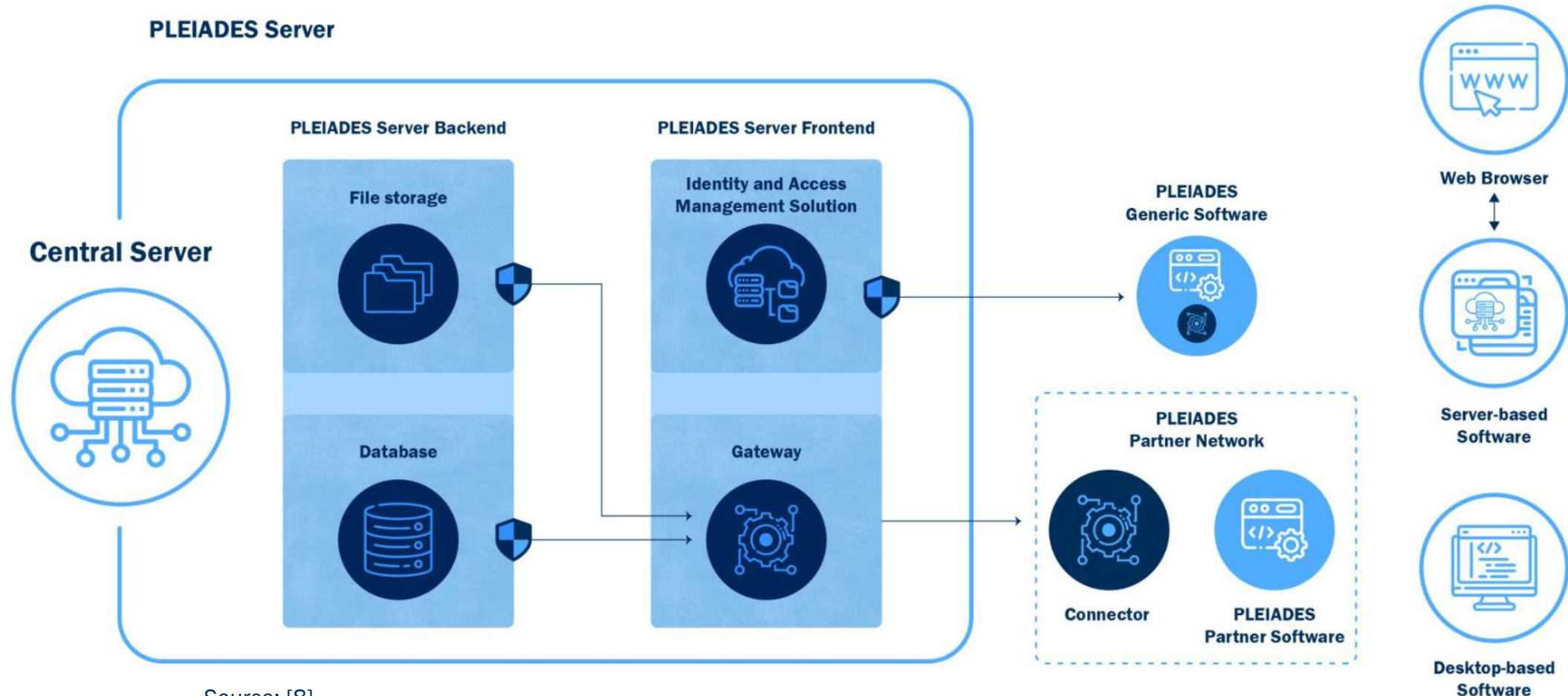


Source: [7]

- Definition of 6 user stories (US)
 - **US#1:** Manual vs. remote radiological characterization;
 - **US#2:** 3D supported vs. digitally enhanced dismantling;
 - **US#3:** Manual vs. automated decontamination of building surfaces;
 - **US#4:** Strategic risk management planning;
 - **US#5:** Regulatory/TSO review capabilities;
 - **US#6:** Strategic waste management planning.

Results: PLEIADES Platform Development

- After being specified, developed and tested, the platform is operational



Source: [8]



Results: Development of Digital Models

- Implementation on real use cases

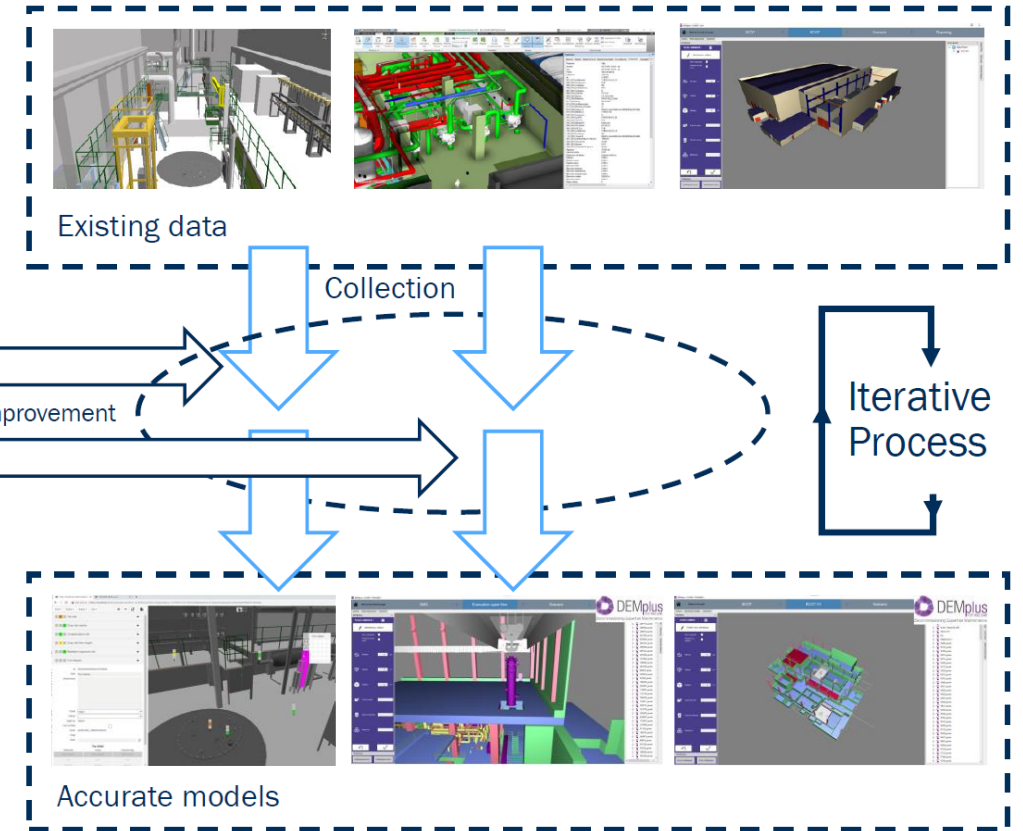
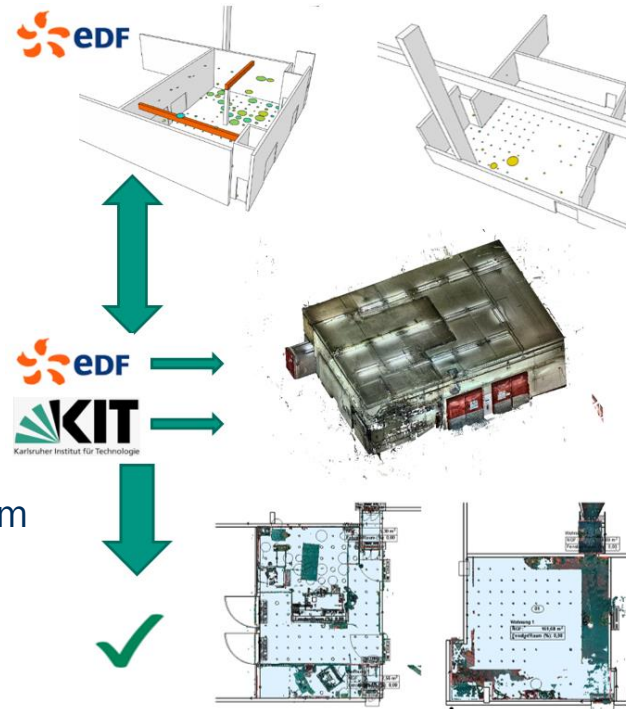
- Input

- Physical inventory, features;
 - Radiological inventory.

- Activities

- Analyze inputs;
 - Identify gaps and problems;
 - Propose and perform activities to complete the models.

- Output



The Use of Digital Models

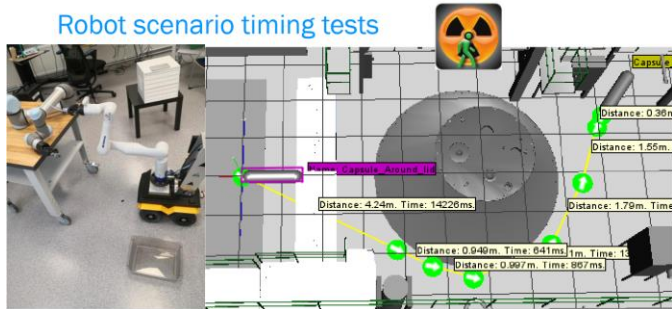
- Some examples of simulations

Halden Research Reactor (HRR)



US#1: Manual vs. remote radiological characterization

Robot scenario timing tests



Source: [11]

HVRC VRDose®

Scenario	Dose (mSv)
Radiation Protection (manual scenario)	0.027 mSv
Radiation Protection (robot scenario)	0.018 mSv
Worker (manual scenario)	0.021 mSv
Worker (robot scenario)	0.022 mSv
Supervisor (manual scenario)	0.023 mSv
Supervisor (robot scenario)	0.023 mSv

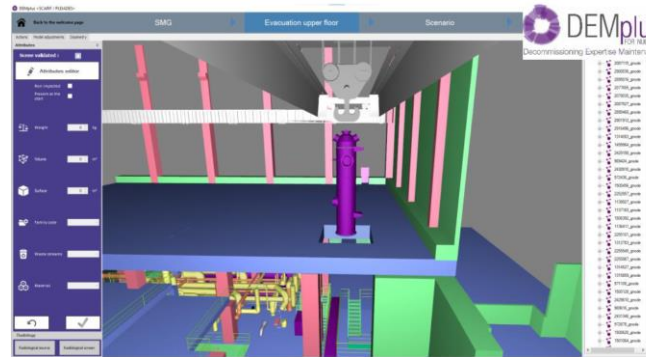
US#4: Strategic risk management planning

Santa María de Garona (SMG)



US#2: 3D supported vs. digitally enhanced dismantling

SMG 3D model visualization on DEMplus®



Source: [13]

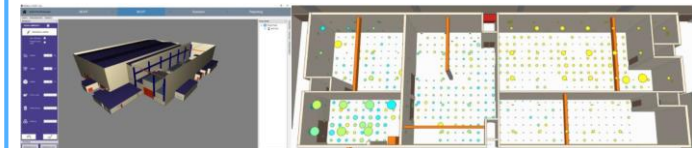
US#5: Regulatory/TSO review capabilities

Basse Chaude O. du Tricastin (BCOT)

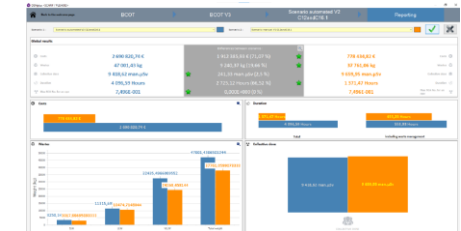


US#3: Manual vs. automated dec. of building surfaces

Test and results from DEMplus® scenario simulations



Source: [12]



US#6: Strategic waste management planning

- Decommissioning planning activities demonstrated:

Cost estimation, waste estimation, dismantling visualization, risk management, TSO/regulatory reviews



Summary

- Core **nuclear decommissioning ontology** was developed;
- **Open, robust and flexible platform** for digitalization of decommissioning planning implemented;
 - Open = the API interface is publicly available;
 - Robust = large amount of data can be processed (3D models, point clouds, structured data);
 - Flexible = any software, independent from the technology, can connect and benefit from the common data environment.
- Successfully demonstrated on **6 user stories** utilizing various technologies like 3D modelling, VR/XR, computational analysis used at different stages of decommissioning planning.



Further Steps

- Continue in the development of the ontology and the API;
- Extend the coverage of the decommissioning planning activities that can be supported by the PLEIADES platform;
- Utilization of other digitalization technologies like artificial intelligence, robotics or integration with sensor networks.



Source: [14]

Sources

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